Eliminating myoglobin from blood using IV filter

Technical Field

Myoglobinemia means the presence of myoglobin (an 18,800-Dalton Oxygen carrier
ptn. present in the sarcoplasma of muscles).
It happens in some cases, we are concerned here with acute traumatic causes of crushing muscles, e.g. crush syndrome or falling objects in disasters.

Rhabdomyolysis is the breakdown of striated muscles.
It leads to the release of intra muscular components to the I.S.F.
One of the key compounds released is myoglobin (oxygen carrier resembles
hemoglobin but with only one haeme moiety).
Other components are Calcium, phosphorus, potassium, & nucleosides (metabolized later in the liver into xanthine, hypoxanthine &uric acid)

Most important causes of rhabdomyolysis are:

1) Trauma & compression in accidents, crush syndrome, earth quakes, war
disasters, & long term confinement in the same position (e.g. orthopedic problems &
interventions necessitating specific position for long time)
2) Occlusion of muscular vessels: thrombosis, occlusion, or clamping

3) Drugs & toxins: alcohol, heroin

Pathology of myolysis:

Muscle lysis occurs by 3 ways:

Changes in cellular metabolism:

Ending in calcium entrance & so persistent contraction & cell death & free oxygen radicals production. It is invaded by activated neutrophils too which produce protons & free radicals

Reperfusion injury

In ischemic injury, most of the damage happens after restoration of blood flow; leukocytes migrate into the damaged tissue only after reperfusion. & free radical production starts only when Oxygen is amply available

Compartment syndrome

If the energy dependant transcellular pump system ,the muscle cells swell & so inter compartmental pressure rises [>30 mmHg produce clinically significant muscle ischemia , in hypotensive patients, even lower compartmental pressure will cause reperfusion problems]

Metabolic derangement during rhabdomyolysis

The release of constituents of necrotic muscles results in alteration of plasma concentration of several compounds.

If A.R.F. develops, it aggravates the condition

Myoglobin: it is our enemy here

Fluids: Massive amounts of fluids accumulate in the affected limb (up to 10 liters per limb). Loss of that amount may lead to shock, hypernatremia, & deterioration of renal function if not replaced

Potassium: massive amount of potassium is released (which can't be eliminated by the kidney if ARF develops)

Calcium & phosphorus: released & may deposit in tissues

Nucleosides: released from disintegerating muscle cell nuclei to the blood & metabolized in liver into xanthine, hypoxanthine, & uric acid

Organic acids: their release (in addition of the production of uric acid from metabolized nucleosides) cause a high anion gap

Pathophysiology of ARF:-

Myoglobin is easily filtered through the glomerular basement membrane.

Water is progressively reabsorbed into the tubules & so the concentration of myoglobin rises proportionately until it precipitates & causes obstructive cast formation.

Low pH (Acidosis) favors the precipitation of myoglobin & uric acid.

Haeme centre of myoglobin initiates lipid peroxidation & renal injury.

Degradation of intratubular myoglobin results in the release of free Iron which catalyze the release of free radicals & further enhances ischemic damage

That leads to death in 20-50% of cases

Background Art

Prevention & treatment:-

The main aim of therapy is to prevent factors which cause ARF, i.e. volume depletion, aciduria, tubular obstruction, & free radicals production

That is tried through:

A) Opening a line even before the patient is still being extricated.

B) Administering fluids, mannitol, sodium bicarbonates, etc. through this line.

Fluids are added up to 10Liters/limb to prevent hypovolemia.

In cases in which muscles are compressed due to trauma, administration of fluids must begin before the victim is extricated from under the rubble

Sodium Bicarbonates: useful in correcting acidosis, & so to prevent precipitation of myoglobin in renal tubules.

It also reduces the risk of hyperkalemia.

Mannitol: used because

1) it increases RBF & GFR
2) it is an osmotic agent that attracts fluids from interstitial compartment , & thus counterbalancing hypovolemia & reducing muscular swelling & nerve compression
3) it is an osmotic diuretic that increases urine flow & prevent cast formation
4) it scavenges free radicals

Extracorporial Blood Purification:

Once ARF or severe hyperkalemia & acidosis are established, patient needs dialysis.

It is supposed to be the only hope for patients for life.

Haemodialysis is used.

Peritoneal dialysis is not performed.

Plasma exchange has no demonstrated benefit because the metabolic turn over of myoglobin is fast.

During reperfusion operations in ischemic cases (e.g. empolectomy), venotomy is described to evacuate the first 500ml of venous blood returning after removing the obstruction to the arterial tree in order to get rid of most of the harmful compounds in the blood

Defect in Background art

- Wasting 500 cc is not accepted, especially for traumatized patients who are already bleeding as it would aggravate their hypovolemia

- Peritoneal dialysis is not possible to patients with traumatized abdomen & any way it would be inefficient.

- Extra Corporial blood purification is a supportive treatment aiming at passing the ARF period but not directed towards counteracting the cause of the problem

  Also it requires either transporting the ill traumatized patients to a near by well equipped place, or to transport a full equipped dialysis unit to the site of disaster.

- It also requires continuous anticoagulation (notice that we are talking about traumatized patients)

- Death Rate hasn't shown a considerable rise during the last 20 years (even with dialysis), which makes prevention of ARF an absolute priority

Disclosure of invention

New Concepts

1) Directing the effort towards trapping myoglobin itself while it is still in the venous blood stream **before it reaches the heart** to be bumped all over the body and cause its damage by means of an attracting filter.

That method is directed towards the **main cause** of problem, **NOT** towards **passing the period** of its harmful effect.

That increases the efficiency of this method over other methods depending on treating the effect of myoglobin excess in the blood.

2) That filter is **easily administered** (same method of introducing a central cannula) which is a routine procedure being already done in such cases .

3) The filter is then **removed almost instantaneously** before it can have chance to cause either anaphylaxis or thrombus,

It even will be coated with myoglobin all around (which is a normal blood component) & so will never cause anaphylaxis if left for a time more than required (e.g. Because of being busy with large number of victims in cases of disasters).

4) The procedures of introducing & removing the filter are *simple* **percutaneous** procedures without complicated invasive techniques which need highly qualified personnel.

5) The functionally active area of the filter is **ALL its length** already present in the blood stream from its point of introduction till its end; that's because

it doesn't trap the myoglobin returning from the injured limb only, but also from the major circulation all over the body through both vinae cavae

6) This procedure is directed towards **all cases of rhabdomyolysis**, especially for **"Insitu Prevention of ARF"** in cases of Disasters, crush injuries, reperfusion injury in a limb either During operative reperfusion or in cases of disasters

Details

Trapping myoglobin is achieved by the introduction of a myoglobin trapping filter in the vein draining the affected area or limb (e.g. the femoral vein in case of lower limb) or through the I.J.V. in a way similar to that of introducing an I.V.C. filter which protects from empolization in case of D.V.T.

As shown in figure 1, that filter is a rod consisting of a central axis of any suitable wire(1), sheathed by latex (2) coated with antimyoglobin antibodies(3).

It can be introduced to the I.J.V. through an opening made by a cannula(4).
It should be introduced in the same procedure of opening I.V. line, before extrication of the victim.

It begins to function just as it is introduced into the blood stream ..
If some myoglobin particles escaped the whole length of the filter & reached the heart, it could be trapped in the next blood circulation (notice that it's present along the I.J.V., the S.V.C., right atrium, I.V.C. & may be the femoral vein).

It should be left in place until the antimyoglobin antibodies are saturated or until the danger is over, Then it should be removed.

Another one may be introduced if needed either simultaneously or consequently.

Description of drawings

1) A central wire
2) Latex coat
3) Antimyoglobin antibodies
4) A Cannula

Where appropriate to carry out this method

This method is directed to all cases of Rhabdomyolysis, especially for "In situ prevention" in cases of disasters; crush syndrome; and "reperfusion injuries.

Industrial applicability

Using antibodies coated latex particles is a commonly used technique in medical field.

Latex is supported in many forms & can b ordered as needed.

Also antimyoglobin antibodies are already available in the market for various uses.

Wide scale usage of this device would reduce its cost, which is - in relation to human life - very cheep.